ABSTRACT

Title: Vibration Based Damage Assessment of Frame Structures using Unified Particle Swarm Optimization

In order to maintain the safety and reliability of the structure it is necessary to inspect its condition regularly for any defect. The present practices for nondestructive evaluation of structural damages mostly include either visual inspection or localized experiment. However, difficulties faced by these procedures in development of a computer based automated evaluation process lead to research for global damage detection method. Vibration parameters of a structure are functions of the physical parameters (i.e. mass, stiffness and damping) and thus the existence of damage leads to changes in these properties. Therefore, an inverse relationship may be formulated among changes in modal parameters and changes in physical properties which can be used for damage assessment. Moreover vibration characteristics of a structure are global in nature and hence it can be a potential candidate for global damage detection.

Most of the vibration based damage assessment techniques follow more or less same approach. Firstly, a mathematical relationship is constructed between damage condition and changes in structural response due to this. Then an objective function is defined using vibration parameters identified from modal testing and corresponding values calculated from finite element simulation. Finally, inverse problem is formulated using a suitable optimization technique to optimize this objective function. The mathematical relationship between structural vibration response and the location and extent of damages is very complex and involves a large number of local optima. This makes the problem more difficult to be solved by conventional optimization algorithms. However, it is possible to circumvent this difficulty with the use of computational intelligence techniques as an effective alternative.

Particle swarm optimization (PSO) is relatively a new kind of computational intelligence method, which mimics the collective motion of insects and birds, trying to reach an unknown destination. Due to its simplicity and convergence speed, PSO has found its application in many complex engineering optimization problems including structural design optimization and structural damage detection. The present study is focused on developing a numerical algorithm for detection and quantification of damages such as cracks and joint damages in structural system using PSO algorithm. In order to realize this goal, the scope of the present research has been defined as follows: (i) finite element formulation of undamaged and damaged structures for obtaining different kind of responses, (ii) construction of inverse problem for damage assessment of structures using PSO, (iii) assessment of locations and depth of cracks in frame like structures without and with noisy set of data, (iv) detection and quantification of damages in semi-rigidly connected structures, (v) damage assessment in large structures by sub-structuring method, and (vii) experimental validation of the developed procedure. A computer code in MATLAB environment is developed for dynamic analysis and damage assessment of structural system. This developed code is applied for assessment of crack and joint damages in several types of skeletal structures such as beams, trusses and frames. The outcomes of the results are found to be very encouraging.